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Serie Havundersøkelser

(Report on Norwegian Fishery and Marine Investigations)
Vol. IX, No. 13

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THE WHIRLING VESSEL

An apparatus for the fractioning of plankton samples.

by
KRISTIAN FREDRIK
WIBORG

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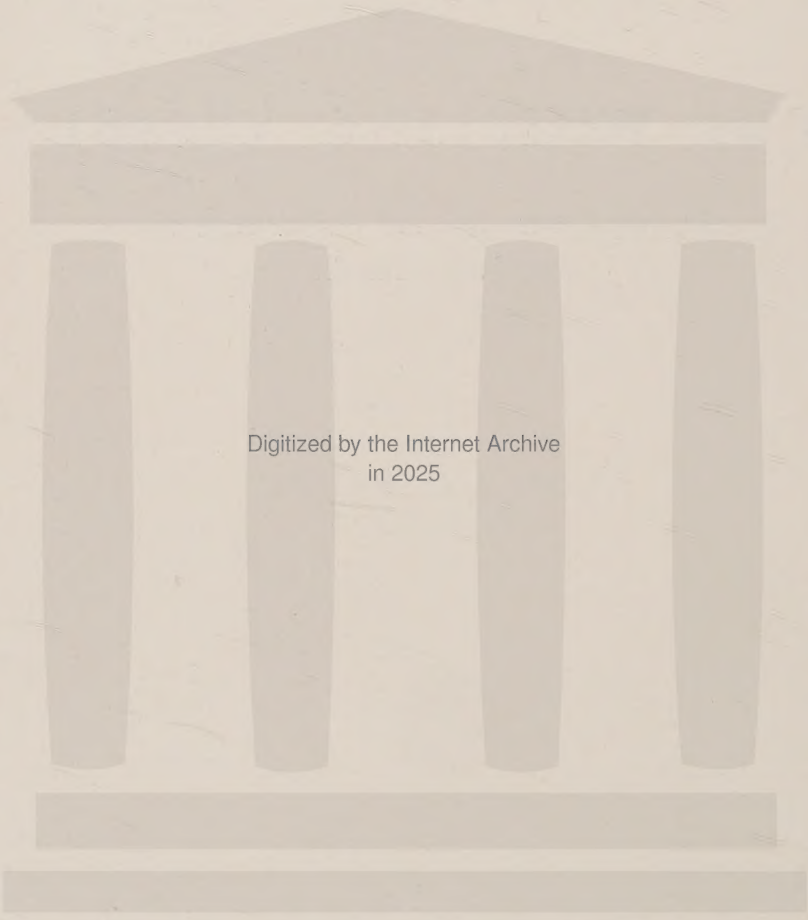

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In quantitative plankton research much time and effort has been spent in finding reliable methods both for the collection of plankton samples from the sea and for the working up of the material in the laboratory. During the first step in the investigations, the collection of the samples, we have to consider a number of factors which influence and modify the reliability of the sampling.

In a limited area of the sea the plankton is not always uniformly distributed, but may occur in patches. In one and the same locality there may be considerable variation both in the composition and the quantity of plankton during a short period of time, due to displacement of the organisms by vertical movements or by currents. Regarding the gear used for sampling, even the same net will not always work in the same way. Variations may occur caused by different ways of handling of the net, by the age of the net, different degrees of clogging, and last but not least, by the random error.

Several workers have shown that in series of plankton hauls, taken from a restricted area within short intervals of time, the size of the catch may vary considerably. GARDINER (1931) found in vertical hauls with the International net that deviations from the mean catch of ± 33 % must be considered as fairly good, but that single hauls might differ as much as 90 % from the mean.

We must also remember that no net or gear will in one single haul catch a representative sample of all the organisms present in the water mass filtered. There will always be some kind of selection, dependent on the kind of gear used.

It is easily understood that as such great variations may occur already during the sampling of the plankton it will not be necessary to claim painstaking accuracy when calculating the total number of organisms in the samples. Most often it is sufficient to count the number of organisms in a small fraction of the sample. We have only to ensure that the numbers counted are not so small as to give improbable results, and that

systematic errors are avoided in the methods used for the fractioning of the samples.

One of the first and simplest methods used for subsampling was to make the sample up with liquid to a known volume, then to stir vigorously

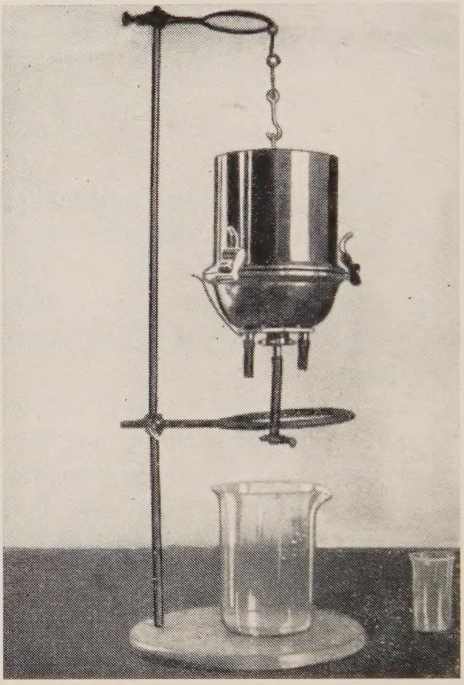

Fig. 1. The whirling vessel, suspended on a stand.

and finally take a subsample with a dip bowl or a stempel pipette. This method is still in use. Another method is to drain off the liquid from the plankton sample, distribute the plankton evenly on a silk net and count the number of organisms in an arbitrary fraction. The fraction and the whole sample are weighed separately and the number of organisms calculated for the whole sample (HJORT and RUUD *1927)*.

Still another method is to count some hundreds of the organisms taken at random and calculate the relative importance of the different species. This method has been used especially for copepods (HJORT and RUUD 1927).

The *whirling vessel* was originally designed by E. LEA and G. ROLLEFSEN at the Fisheries Directorate, Bergen, about 1930 and demonstrated at one of the International Council's meetings in Copenhagen. It

consists of a cylindrical container made in two parts. The bottom part is divided by radial walls into 10 sector compartments of equal size. The apparatus is suspended on a stand, and the plankton sample poured into the container together with a convenient amount of liquid. By rotating the vessel and then suddenly stopping it the plankton is distributed evenly in the container. The plankton is allowed to drain off through holes, covered by silk, in the middle of the cylinder. Then the fractions can be taken out from the individual sectors through holes in the base of the cylinder.

The whirling vessel has been used for many years for fractioning of

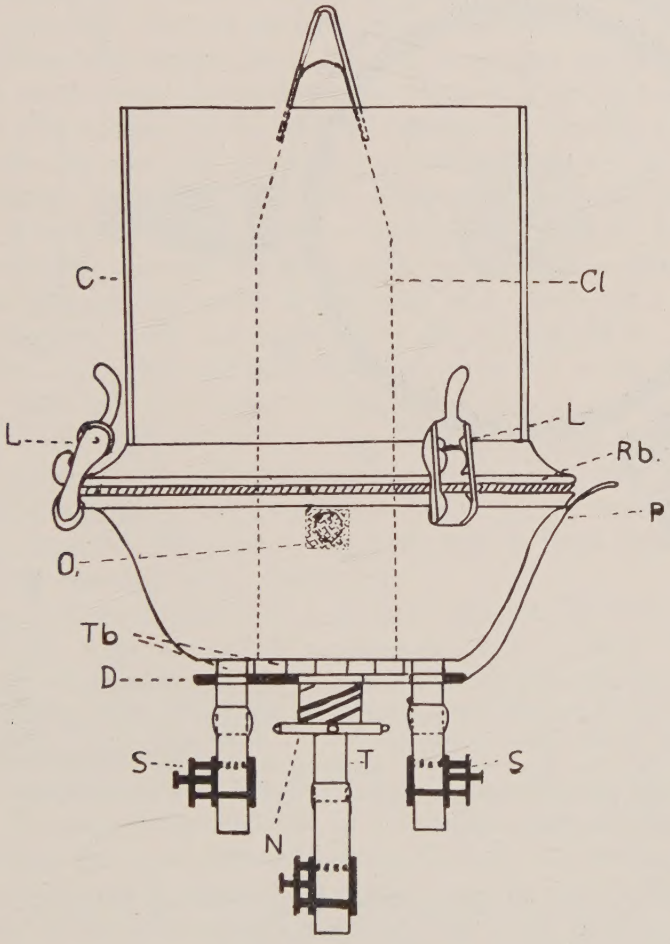

Fig. 2. Transverse section of the whirling vessel. C outer cylinder, Cl inner cylinder. L locks, Rb rubber sheet, P lever, O_1 opening in the inner cylinder, covered by plankton silk, Tb tubes of the sector compartments, D movable disc, N nut, T central tube, S clamps.

plankton samples in Norwegian laboratories, but has never been described. GIBBONS (1933) having seen the whirling vessel, constructed a similar apparatus.

During the last years the whirling vessel has been changed and im-

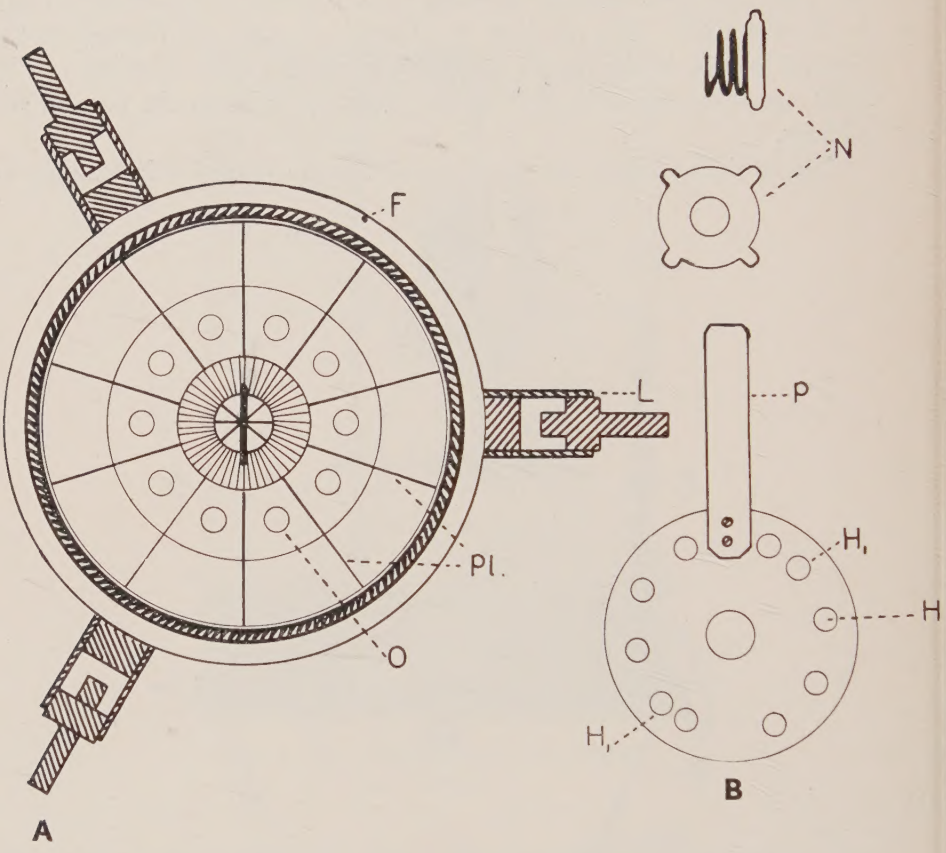

Fig. 3. The base of the whirling vessel (A) and the movable disc (B) seen from above. In A: F peg corresponding with a hole in the outer cylinder. L locks. O opening of the sector compartments. Pl radial walls. In B: H_1 holes corresponding with the short tubes of emptying the marked compartments, H holes for emptying the other compartments. N nut used in attaching the disc to the bottom of the whirling vessel.

proved by the present author, and in the following paragraph a detailed description is given of the new model (fig.s 1—3).

The apparatus is made of nickelized brass and is 20 centimeters high. The outer cylinder (C) is fastened to the lower part of the vessel by means of 3 locks (L). A small peg (F) on the wall of the lower part corresponds with a hole in the cylinder. A rubber sheet (Rb) between

the two parts prevents leakage. In the centre of the vessel there is a cylinder (Cl) ending in a tube (T) in the bottom of the vessel. The space between this cylinder and the outer wall is divided by metal membranes (Pl) into 10 sectors of equal size, each being connected with the interior of the cylinder by an opening (O_1) a little below the upper edge of the membrane. The openings are covered by pieces of plankton silk of the same or smaller mesh size than that of the gear used for collecting the plankton. The plankton silk is glued on to the cylinder with a solution of celluloid. In the bottom of each sector there is another opening (O) ending in a short tube (Tb) . Underneath the vessel there is a circular, plane-ground disc (D) which has an opening in the centre and 10 concentric holes (H). Two of the holes (H_1) have short tubes fitted with rubber tubing and clamps (S). The disc is pressed against the outer openings of the sector compartments by means of a spring held in place by a nut (N) and may be turned into different positions by a lever. In one position the tubes Hl correspond with the openings of two marked compartments, the others then being closed. In the second position of the disc these 8 compartments will be open. In the figure the two sectors are diametrically opposite, but choice of any other two compartments can be made. The whirling vessel is suspended on a stand from a swivel so that it may turn freely and easily. (Fig. 1). A ring can be moved up and down on the stand and be fastened by means of a screw.

The fractioning of plankton samples is carried out as follows: The disc (D) is at first turned until the tubes correspond with the two marked compartments, and all clamps (S) are screwed tight. The vessel is half filled with water and the plankton sample poured into it. If larger plankton organisms are present, e.g. adult krill or large medusae, they ought to be removed before fractioning.

Using both hands the vessel is given a rapid rotation and then stopped suddenly. This operation is repeated two or three times. The walls of the sector compartments act as shovels, stirring up the plankton and distributing it evenly in the vessel. The inner cylinder prevents the formation of a central eddy.

The apparatus is now left for a short time until the plankton has settled. The ring is then moved up below the vessel and fastened, in order to keep the vessel immobile during the following operations. The stopper of the central tube (T) is opened, and the water will flow out until walls of the compartments stand well above the surface.

If the plankton sample contains much phytoplankton, (e.g. *Phaeocystis)* protozoans (e.g. *Collozoum)* or medusae, especially siphonophores, the settling will require some time, and the draining of the water will be made difficult by the clogging of the sieves. The best thing to do is to

make the vessel immobile by use of the ring, close the opening of the central rubber tubing with the left hand's forefinger, and with the right hand squeeze the rubber tubing several times. The plankton will then be removed from the sieves. If the plankton samples consist of copepods containing much oil, the sieves will also become clogged after some time. The vessel must then be cleaned with soap and water. If the sieves are still clogged, they must be changed. Sometimes the plankton organisms float when the water is added. This can be avoided by using water which has been in the room for some time and is in equilibrium with the atmosphere.

After draining off the water the cylinder (C) is removed, the marked compartments opened by unscrewing the clamps and the contents washed into small glass beakers. Finally, a larger beaker is placed below the vessel, the disc turned and the remaining compartments emptied *en bloc*. A wash bottle is used to remove all the plankton from the vessel.

If there still are too many organisms in the subsamples, one of these is fractioned. The other one is kept for the counting of less numerous organisms.

The subsamples are sieved through a sieve made of plankton silk, and the plankton carefully transferred to a glass plate by means of a thin metal spatula and a fine brush. The counting is carried out under a binocular microscope, the organisms being examined and sorted using shafted needles. Liquid is added with a pipette during the counting to prevent the sample drying.

The different operations needed for the fractioning of the plankton samples with the whirling vessel do not require much time. When working with a series of plankton samples one can finish the counting of one sample while the next is settling in the vessel, and while the water is draining off. The actual time required is then restricted to the pouring of the sample into the vessel, rotating, taking out the subsamples, and washing out the vessel. Roughly calculated all these operations will take 5—10 minutes per sample.

I order to test the efficiency of the apparatus an artificial plankton sample was made up consisting of 1000 cod eggs, 1000 copepodites stage IV—VI of *Calanus finmarchicus* and 100 larvae of *Sebastes marinus*. This sample was fractioned 10 times, and in each experiment the contents of all the compartments were counted. For this purpose we used a disc with one single opening. The results of the experiments are given in table 1. A few individuals were sometimes lost during the operations and some new ones added, so that the numbers are not always exactly alike.

When we take a fraction out of a sample of a number of units, e.g.

Table 1. Experiments with whirling vessel. Fractioning of a sample of 1000 cod eggs. 1000 Calanus finmarchicus stage IV-VI and 100 Sebastes marinus larvae.

Room No.	Exp. No.	1	2	3	4	5	6	7	8	9	10	Total
I	Eggs	126	111	107	80	108	97	102	103	84	108	1 026
	Copepods	98	104	104	83	109	91	87	97	108	108	989
	Larvae	6	9	7	7	15	10	8	12	8	9	91
	Total	230	224	218	170	232	198	197	212	200	225	2 106
II	Eggs	89	104	109	97	94	98	96	98	98	103	986
	Copepods	78	103	99	108	97	119	100	98	100	94	1 001
	Larvae	16	5	4	7	8	18	10	7	8	11	94
	Total	183	112	212	212	199	235	206	203	206	208	2 081
III	Eggs	80	92	99	96	98	94	116	87	120	97	979
	Copepods	97	105	80	94	100	81	102	95	104	101	959
	Larvae	5	11	8	4	9	9	5	9	12	11	83
	Total	182	208	187	194	207	184	223	191	236	209	2 021
IV	Eggs	109	85	97	96	101	101	100	93	90	108	980
	Copepods	88	99	98	99	116	102	96	108	99	103	1 008
	Larvae	13	11	9	11	5	10	8	12	9	6	94
	Total	210	195	204	206	222	213	204	213	198	217	2 082
V	Eggs	100	96	82	91	98	119	97	108	106	100	997
	Copepods	101	95	95	110	105	104	114	98	106	106	1 034
	Larvae	6	12	16	11	13	9	13	15	14	11	120
	Total	207	203	193	212	216	232	224	221	226	217	2 151
VI	Eggs	101	95	89	105	97	110	118	104	107	95	1 021
	Copepods	97	101	124	114	91	119	112	104	101	113	1 076
	Larvae	9	10	9	13	11	7	15	7	6	8	95
	Total	207	206	222	232	199	236	245	215	214	216	2 192
VII	Eggs	124	101	113	100	99	96	91	108	95	107	1 034
	Copepods	117	100	95	117	104	87	89	105	91	110	1 015
	Larvae	12	10	19	10	9	10	10	10	7	13	110
	Total	253	211	227	227	212	193	190	223	193	230	2 159
VIII	Eggs	93	103	95	127	93	95	82	93	96	108	985
	Copepods	114	93	98	97	92	100	101	119	93	105	1 012
	Larvae	13	10	9	10	6	6	5	8	9	10	86
	Total	220	206	202	234	191	201	188	220	198	223	2 083
IX	Eggs	97	117	104	118	117	93	109	125	101	100	1 081
	Copepods	110	89	113	105	94	114	105	102	103	85	1 020
	Larvae	11	10	11	9	12	7	18	12	15	10	115
	Total	218	216	228	232	223	214	232	239	219	195	2 216
X	Eggs	78	81	87	93	97	99	91	83	105	76	890
	Copepods	94	101	85	81	97	87	100	76	99	79	899
	Larvae	8	12	8	18	10	12	9	9	11	12	109
	Total	180	194	180	192	204	198	200	168	215	167	1 898
Total numbers in sample	Eggs	997	985	982	1003	1002	1002	1002	1002	1002	1002	9 979
	Copepods	994	990	991	1008	1005	1004	1006	1002	1004	1004	10 008
	Larvae	99	100	100	100	100	98	101	101	99	99	997
	Total	2090	2075	2073	2111	2107	2104	2109	2105	2105	1205	20984

plankton organisms, we will seldom get exactly the number which is expected. There will nearly always be a deviation caused by the random error. The average deviation is dependent on the number in the total sample and can be calculated by statistical methods. In the experiments with the whirling vessel I have used the χ^2 — method of Fischer as shown by BONNIER—TEDIN (1940). For each compartment in the vessel we get the equation: $\chi^2 = \frac{d^2}{m} + \frac{d^2}{9m}$ where d is the difference n÷m between the actual number found n, and the expected number m, and 9m the number expected in the 9 remaining rooms. This system has one degree of freedom. The values of χ^2 have been calculated for each individual compartments of the vessel for fish eggs, copepods, fish larvae and total number in all the experiments taken together (table 2), and for each single experiment (table 3 page 13).

Some of the compartments gave quite high values of χ^2, e.g. room III for fish larvae, room VI for copepods and especially room IX and X for eggs, copepods and total number. It is however to be expected that in a series of experiments some of the values will be extreme ones.

In order to see how the individual experiments varied *inter se*, a test of *heterogenity* was made (table 3), and the corresponding values of probability *P*, were drawn from given tables (BONNIER—TEDIN). It will appear from table 3 that the very low P-values found for some of the compartments, II and VII, can be traced back to single extreme values of χ^2. For most of the experiments the P-values lie between 0,3 and 0,5.

From what is mentioned above it will be understood that the fraction of the plankton sample contained in each compartment of the whirling vessels is expected to be proportional to the surface area of the upper opening of the compartment, as delimited by the upper edges of the radial walls, the outer wall of the vessel and the wall of the inner cylinder (see fig. 3). If the apparatus is carefully made, all the 10 openings should be exacly of the same size. —

The area of the upper opening of the different rooms were measured and the relations between the sizes of the openings were as follows (the average opening being 10):

I	II	III	IV	V	VI	VII	VIII	IX	X
10,4	9,7	10,1	9,7	10,3	10,3	9,8	10,0	10,2	9,5

The differences are not very large. The deficit in numbers in room X can possibly be explained by the smaller area of the opening, but there is not sufficient proof that the excess in room IX can be ascribed to a large area of the opening. However, the deviations of these rooms are

Table 2. *Results from 10 combined experiments with the whirling vessel.*

Room No.	I				II				III				IV			
	Cod Eggs	Cope-pods	Fish Lar-vae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total
n	1026,0	989,	91,0	2106,0	986,0	1001,0	94,0	2081,0	979,0	959,0	83,0	2021,0	980,0	1008,0	94,0	2082,0
m	997,9	1000,8	99,7	2098,1	997,9	1000,8	99,7	2098,1	997,9	1000,8	99,7	2098,1	997,9	1000,8	99,72	2098,1
d	28,1	11,8	8,7	7,9	11,9	0,2	5,7	16,9	18,9	41,8	16,7	76,9	17,9	7,2	5,7	16,1
d^2	789,6	139,2	75,69	62,4	148,0	0,04	32,49	292,4	357,21	1747,2	278,9	5791,2	320,4	51,8	32,5	259,21
χ^2	0,880	0,155	0,844	0,033	0,156	0,00005	0,362	0,154	0,398	1,94	4,232	3,066	0,357	0,058	0,36	0,137

Room No.	V				VI				VII				VIII			
	Cod Eggs	Cope-pods	Fish Lar-vae	Total	Cod Eggs	Cope-pods	Fish Lar-vae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total
n	997,0	1034,0	120,0	2151,0	1021,0	1076,0	95,0	2192,0	1034,0	1015,0	110,0	2159,0	985,0	1012,0	86,0	2083,0
m	997,9	1000,8	99,7	2098,1	997,9	1000,8	99,7	2098,1	997,9	1000,8	99,7	2098,1	997,9	1000,8	99,7	2098,1
d	0,9	33,2	20,3	52,9	23,1	75,2	4,7	93,9	36,1	14,2	10,3	60,9	12,9	11,2	13,7	15,1
d^2	0,81	1102,24	412,09	2808,4	532,0	5655,04	22,09	8817,2	1301,0	201,6	106,1	3708,8	166,0	125,4	187,7	228,01
χ^2	0,0009	1,223	4,59	1,488	0,592	6,278	0,246	4,76	1,45	0,224	1,182	1,964	0,185	0,139	2,091	0,121

Room No.	IX				X			
	Cod Eggs	Cope-pods	Fish Lar-vae	Total	Cod Eggs	Cope-pods	Fish Lar-vae	Total
n	1081,0	1020,0	115,0	2216,0	890,0	899,0	109,0	1898,0
m	997,9	1000,8	99,7	2098,1	997,9	1000,8	99,7	2098,1
d	83,1	19,2	15,3	117,9	107,9	101,8	9,3	200,1
d^2	6905,6	368,64	234,09	13900	11 620	10363	86,49	40050
χ^2	7,700	0,409	2,615	7,361	12,94	11,506	0,966	19,21

n = numbers found
m = numbers expected
d = n-m

$$\chi^2 = \frac{d^2}{m} + \frac{d^2}{9m}$$

not very great, about 10 % on average in a sample of 1000 specimens. The average percentage deviation for all the rooms is 8.3 for cod eggs and 6.9 for copepods. The maximum percentage deviation is 26.5 and 25.1 for eggs and copepods respectively.

When the sample to be fractioned is smaller, the percentage deviation increases. In the fractioning of a sample of 100 fish larvae the average deviation is 24,1 % and the maximum individual deviation 80 %. However, when organisms occur sparsely in a plankton sample, they are counted in two or more fractions, or, if it is important to know the exact number (e.g. of fish larvae), in the entire sample. In any case the order of size of the figures will be known.

It might be supposed that errors would occur if the plankton sample was unevenly distributed in the vessel. This might happen if the organisms in the plankton sample, when poured into the vessel, immediately sank to the bottom of the compartments and that the shoveling action of the radial walls was insufficient to send them out again. In order to test this hypothesis the entire plankton sample was emptied into one of the compartments, water added very carefully so that the organisms remained in the compartment, and the vessel rotated two times as usual. The organisms from the same compartment in which the sample had been placed, were then counted. This experiment was repeated three times. The numbers found did not differ from what had been found in the ordinary experiments, and this was regarded as a proof that the rotation of the vessel is sufficient to ensure an even distribution of the sample over all the compartments.

As a conclusion it may be said that the whirling vessel has proved to be a reliable instrument for the fractioning of plankton samples.

SUMMARY

A description is given of the whirling vessel, an apparatus for the fractioning of plankton samples. Statistical tests have proved that the apparatus works reliably.

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Table 3. *Distribution of χ^2 in the experiments with the whirling vessel and heterogenity tests of the individual rooms.*

Room No.	I				II				III			
Experiment No.	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total
1	7,708	0,021	1,707	2,344	1,277	5,240	4,177	3,063	4,325	0,064	2,696	3,877
2	1,763	0,280	0,111	1,564	0,341	0,180	2,777	0,108	0,477	0,404	0,111	0,013
3	0,877	0,269	1,000	0,613	1,319	0,0001	4,000	0,118	0,007	4,090	0,445	2,208
4	4,557	3,492	1,000	8,504	0,121	0,511	1,000	0,004	0,205	0,510	4,000	1,539
5	0,663	0,765	2,780	2,150	0,426	0,136	0,444	0,721	0,054	0,003	0,111	0,072
6	0,114	0,980	0,005	0,812	0,054	3,830	7,626	3,197	0,426	4,175	0,073	3,681
7	0,036	2,040	0,485	1,018	0,196	0,004	0,001	0,127	2,769	0,028	2,863	0,772
8	0,087	0,113	0,397	0,012	0,054	0,054	1,054	0,297	1,932	0,299	0,133	2,007
9	2,910	0,639	0,405	0,593	0,054	0,002	0,405	0,107	4,347	0,143	0,495	3,434
10	0,535	0,527	0,072	1,054	0,087	0,453	0,136	0,033	0,114	0,004	0,136	0,001
$\sum_{1}^{10} \chi^2$	19,250	9,076	8,661	18,664	3,929	10,187	21,620	7,775	14,656	11,720	11,063	17,604
χ^2 comb. exp.	0,880	0,155	0,844	0,033	0,165	0,0005	0,362	0,151	0,398	1,940	4,232	3,066
Heterogenity χ^2	18,370	8,921	7,817	18,631	3,764	10,187	21,268	7,624	14,258	9,780	6,831	14,538
$< P <$	0,05-0,02	0,5-0,3	0,5-0,3	0,05-0,02	0,95-0,9	0,5-0,3	0,02-0,01	0,7-0,5	0,2-0,1	0,5-0,3	0,7-0,5	0,2-0,1

Table 3. (*cont.*)

Room No.	IV				V				VI			
Experiment No.	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total
1	0,964	1,453	1,078	0,005	0,001	0,029	1,707	0,022	0,019	0,064	0,405	0,021
2	2,057	0,000	0,111	0,837	0,070	0,180	0,445	0,108	0,138	0,046	0,000	0,012
3	0,016	0,014	0,111	0,058	2,970	0,189	4,000	1,096	0,957	6,953	0,111	1,158
4	0,205	0,036	0,111	0,137	0,958	0,106	0,1110	0,004	0,245	1,920	1,000	2,299
5	0,007	2,651	2,771	0,689	0,054	0,224	1,000	0,148	0,114	0,998	0,111	0,722
6	0,007	0,028	0,006	0,036	3,919	0,127	0,073	2,460	1,090	3,743	0,889	3,461
7	0,0004	0,233	0,485	0,251	0,114	1,986	0,925	0,904	3,514	1,435	2,642	6,075
8	0,575	0,675	0,397	0,033	0,675	0,054	2,642	0,582	0,160	0,160	1,081	0,107
9	1,152	0,022	0,091	0,824	0,373	0,347	1,887	1,269	0,513	0,004	1,707	0,065
10	0,675	0,075	1,707	0,223	0,0004	0,347	0,136	0,223	0,256	1,758	0,405	0,160
$\sum_{1}^{10} \chi^2$	5,6584	5,187	6,868	3,093	9,1344	3,589	12,926	6,816	7,006	17,081	8,351	14,080
χ^2 comb. exp.	0,357	0,058	0,362	0,137	0,0009	1,223	4,590	1,488	0,592	6,278	0,246	4,670
Heterogenity χ^2	5,301	5,129	6,506	2,956	9,134	2,366	8,336	5,328	6,414	10,803	8,105	9,410
$< P <$	0,9-0,8	0,9-0,8	0,8-0,7	0,98-0,95	0,5-0,3	0,99-0,98	0,7-0,5	0,9-0,8	0,8-0,7	0,3-0,2	0,7-0,5	0,5-0,3

Table 3. (*cont.*)

Room No.	VII				VIII				IX			
Experiment No.	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total	Cod Eggs	Cope-pods	Fish Larvae	Total
1	6,631	3,463	0,495	10,830	0,512	2,383	1,078	0,643	0,081	1,256	0,154	0,431
2	0,071	0,011	0,000	0,065	0,229	0,404	0,000	0,012	3,522	1,123	0,000	0,387
3	2,478	0,189	9,000	2,080	0,116	0,014	0,111	0,151	0,381	2,166	0,111	2,297
4	0,001	0,433	0,000	0,183	7,898	0,159	0,000	2,760	3,470	0,195	0,111	2,299
5	0,016	0,136	0,111	0,009	0,575	0,799	1,778	2,049	3,129	0,467	0,444	0,798
6	0,196	1,988	0,005	0,289	0,300	0,002	1,638	0,467	0,575	2,047	0,889	0,061
7	0,939	1,487	0,011	0,626	3,673	0,002	2,863	2,764	0,859	0,214	6,808	2,346
8	0,575	0,256	0,011	0,825	0,575	3,919	0,485	0,467	6,821	0,036	0,397	4,289
9	0,300	0,978	0,944	1,615	0,196	0,605	0,091	0,825	0,007	0,075	2,920	1,807
10	0,426	1,021	1,078	2,008	0,675	0,234	0,001	0,825	0,0004	2,625	0,001	1,269
$\sum_{1}^{10} \chi^2$	11,633	9,962	11,655	18,530	14,749	8,521	8,045	10,969	18,8454	10,204	12,495	16,184
χ^2 comb. exp.	1,450	0,224	1,182	1,964	0,185	0,139	2,091	0,121	7,700	0,409	2,615	7,361
Heterogenity χ^2	10,183	9,738	10,473	16,566	14,564	8,382	5,954	10,888	11,145	9,795	9,880	8,823
$< P <$	0,5-0,3	0,5-0,3	0,5-0,3	0,10-0,05	0,2-0,1	0,5-0,3	0,8-0,7	0,3-0,2	0,3-0,2	0,5-0,3	0,5-0,3	0,5-0,3

Table 3. (*cont.*)

Room No.	X			
Exp. No.	Cod Eggs	Cope-pods	Fish Larvae	Total
1	5,248	0,326	0,405	4,472
2	3,455	0,045	0,445	0,066
3	1,684	2,229	0,445	3,996
4	0,590	4,321	7,112	1,921
5	0,114	0,136	0,000	0,237
6	0,016	1,988	0,549	0,813
7	0,939	0,004	0,133	0,626
8	3,280	6,494	0,133	9,535
9	0,256	0,973	0,139	0,107
10	6,494	5,070	0,495	9,991
$\sum_{1}^{10} \chi^2$	22,076	21,586	9,856	31,764
χ^2 comb. exp.	12,940	11,506	0,966	19,210
Heterogenity χ^2	9,136	10,080	8,890	12,554
$< P <$	0,5-0,3	0,5-0,3	0,5-0,3	0,2-0,1